



Impregnation is an essential part of mummification

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Abstract

A contemporary prospective experiment, recreating ancient Egyptian practice, demonstrates morphological alterations during mummification. However, in order to emulate the process from antiquity, the conclusive step of mummification – impregnation – has to be taken into account. The present commentary gives a perspective on this topic.

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In their recently published work, Morozova et al. (2019) report a follow-up of a study of experimental mummification, faithfully replicating the ancient Egyptian practice of preserving the dead. The results of this study give a very valuable perspective, which is of use for archaeologists, historians, and forensic specialists alike. In a series of reports, a team of investigators has given detailed account of the tissue alterations in the process of mummification in real time using macroscopic, radiographic, histologic and molecular techniques (Panzer et al., 2013; Shved et al., 2014; Papageorgopoulou et al., 2015). However, according to the most recent update, the experimentally mummified human leg, used in this research, was kept in a natron-like mixture (Morozova et al., 2009) for several years, unlike the procedure in the ancient report by Herodotus of seventy days (Herodot, translated by Kai Brodersen, 2000).

The etymology of the modern English word “mummy” can be traced back to the Persian word for *bitumen*, a black sticky petrol derivate (Granville, 1825, Clark et al., 2018). Even though bitumen was most probably not used in the ancient Egyptian mummification process, the analogy clearly reflects the appearance of the Egyptian mummies – not only with darkened skin, but also covered with a viscous substance. This can be attributed to the treatment with different organic substances. According to the description by the ancient Greek historian of the 5th century BC, Herodotus (Herodot, translated by Kai Brodersen, 2000), following desiccation in natron, the bodies were wrapped in ‘gum’-soaked bandages, while another ancient historian, Diodorus Siculus (Diodorus, translated by Edwin Murphy, 1985), in the 1st century BC, also mentions treatment with cedar oil, myrrh, and cinnamon, among others. Using an *a posteriori* approach, Buckley and Evershed (2001) identify the usage of resinous substances of great compositional diversity in the mummification process throughout Egyptian history.

Impregnation of a previously dehydrated tissue (which was thereby essentially fixed) is the ultimate step in the preservation process (Sivrev et al., 2005). The ancient embalmers recognized the antimicrobial properties of the natural resins and oils (Buckley and Evershed, 2001) and actively implemented them. Moreover, while dehydrated tissue is brittle and fragile,

impregnation with high molecular size compounds gives it a degree of mechanical stability and renders it hydrophobic. Desiccation followed by impregnation is a practice of body preservation kept long after the decline of the Egyptian kingdom. Similar practices have been recorded in the Christian church (Tomov and Dzhangozov, 2018, Tomov et al., 2018), and more recently, in the plastination technique pioneered by Gunther von Hagens (von Horst et al., 2019), however using synthetic rather than natural compounds.

Summarizing the ancient mummification process, we can divide it in two steps. The dehydration in natron aims to remove water from the tissue and to create a hyperosmotic milieu, making bacterial growth unlikely. Subsequent impregnation of the dry brittle tissue with resins and oils confers flexibility, as well as antimicrobial, and hydrophobic properties to the tissue, which would help ensure its resilience against time. Prospective studies of experimental mummification should incorporate the impregnation as a concluding phase of the process in order to give a more complete account of the ancient practice. Given that the components of the impregnating agents are variable, this would provide valuable information on the preserving properties of natural substances and forensic clues towards the mummification practice.

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